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Ms. Carol Browner
The Administrator
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

About: Research on Risk Reduction Options for Particulate Matter 2.5

Dear Ms. Browner:

In 1997, the Environmental Protection Agency issued a National Ambient Air Quality Standard for airborne particulate matter (PM2.5). According to the Agency's timetable for implementing new PM2.5 standards, EPA does not plan to address controls until after the next revision in 2002. To support the revision, Congress has funded research to reduce uncertainties in the generation, transport, and health effects of particulate matter and the National Research Council has developed recommendations on the focus of and conceptual plans for implementing the particulate matter research program.

This commentary addresses the scope and schedule of the Agency's particulate matter research. In developing its recommendations, the Environmental Engineering Committee studied the recommendations of the National Research Council and Agency research plans. The Committee has also consulted with some members of the Clean Air Scientific Advisory Committee and the Research Strategies Advisory Committee.

The National Ambient Air Quality Standard for PM2.5 was based on the suggestion that the size of particulate matter plays a role in adverse health effects. There are indications that many areas will not be in compliance with the new standard. While the Environmental Engineering Committee agrees that the Agency should develop an effective research plan that includes (1) adequate toxicological studies to identify the biologically important constituents of particulate matter, and (2) modeling/correlation studies to relate fixed site outdoor monitoring data to human exposures to particulate matter of outdoor origin, the Committee recommends that the scope and schedule of the research program be adjusted so that research on risk reduction options can be conducted concurrently with studies of health and exposure. If risk reduction options are not identified and evaluated in a timely manner, then, assuming the health and exposure studies confirm a relationship between adverse health effects and exposure to particulate matter in this size range, no risk reduction strategies may be available to meet the need for health protection.

While the Committee encourages the Agency to think broadly about what those risk reduction options might be, the Committee will restrict its further comments to those options with which it is familiar -- source reduction and control technologies. Even with the current limited understanding of the relationship between particulate matter and adverse health effects, the existing research plan could be expanded to include source reduction and control technologies.

The Committee suggests that the Agency consider the following approaches to implementing a source reduction/control technology research program.

1. Use the current knowledge base on health effects of particulate matter to identify issues for source reduction and control technology research.

2. Use the differences in chemical composition to develop source-specific PM2.5 fingerprints. The fingerprints will identify the sources that contribute to ambient particulate matter so that risk reduction options can be implemented and, later, evaluated for effectiveness.

Studying sources, reduction, and controls, concurrent with and as a complement to, the health effects and exposure research should be cost-effective. More importantly, such research will provide risk managers with a timely array of options for reducing risks to the public.

More detailed discussion of the issues outlined in this letter is provided in the Appendix. The EEC looks forward to working with CASAC on technology-related aspects of particulate matter control to provide technical advice to the Agency and other appropriate technical committees.

Sincerely,

JoAnn Slama Lighty
Sub-Committee Chair

Hilary I. Inyang
EEC Chair

Joan Daisy
SAB Chair

APPENDIX: Commentary on The Need to Address Source Reduction and Control Technology In PM2.5 Research Plan

Background on PM Issues

The Clean Air Act requires that EPA periodically review the National Ambient Air Quality Standards and the criteria documents on which they are based. The Agency can then revise or retain the standards as warranted.

In 1971, EPA issued its first Total Suspended Particulate (TSP) National Ambient Air Quality Standard (NAAQS). In 1987, EPA issued a NAAQS for particulate matter (PM10). EPA reviewed the criteria documents and standards for particulate matter during 1994-1997; in 1997, EPA issued a revised NAAQS for PM10 and the first NAAQS for PM2.5 The particulate matter standards were based largely on epidemiological studies which had found relatively consistent (although poorly understood) correlations between ambient concentrations of particulate matter and adverse health effects (NRC, 1998).

The addition of a PM2.5 standard has caused many debates. To obtain more scientific information to assess the standards, Congress funded a major EPA research program ($49.6 million in 1998) and funded a National Research Council (NRC) study to identify the most important research priorities "relevant to setting and reviewing NAAQS for particulate matter, and to monitor and report over 5 years on research progress toward an improved understanding of the relationship between particulate matter and its effects upon public health" (NRC, 1998).

The role of the NRC's Committee on Research Priorities for Airborne Particulate Matter is to identify research priorities, some of which are aimed at linking exposure, health effects, and atmospheric sciences research agendas to develop further understanding of their relation to particulate matter. While the first report (NRC 1998) dealt mainly with health effects, the coverage is likely to broaden in future reports. The second of four planned reports is nearing completion.

The Clean Air Scientific Advisory Committee (CASAC) of the EPA Science Advisory Board advises on particulate matter research because the Clean Air Act (CAA) requires that CASAC review the scientific basis for NAAQS decisions. CASAC has identified the following priority research areas: the effects of exposure to health outcomes; mechanisms by which PM contributes to adverse health effects; linking outdoor monitoring with actual exposure; PM classes and characteristics associated with response pathways and potency; and the extent to which PM causes health effects independently.

<u>Need for Concurrent Research on Risk Reduction Options, Health Effects and Exposure</u>

The risk assessment/risk management paradigm separates risk assessment from risk management, in part, to keep technical and economic constraints from influencing the judgement of the risk assessors. The particulate matter research program appears designed to provide a better understanding of the relationship between particulate matter and health effects. This additional knowledge is needed to support review and revision of the criteria document and standards in 2002.

While this may be sufficient for the risk assessment portion of the risk assessment/risk management paradigm, the health research alone is not sufficient to reduce risks and protect public health. Technology-based research needs to be conducted concurrently with health research so that adequate cost/benefit information will be available for regulatory decision-making. Research is also needed to provide risk managers with options for reducing risks from fine particulate matter. Understanding the nature of sources and their link to ambient PM2.5 is necessary for the development of risk reduction options.

(The Committee notes that, while the recently announced "Particulate Matter (PM) Supersites Program" (March 1, 1999) may provide some information on source apportionment, source reduction and control technology do not appear to be included.)

Knowledge Base on Health Effects and Implications for Research on Risk Reduction Options

Aerodynamic particle size is a predominant determinant of where the particle is likely to deposit in the respiratory tract. Three relevant size ranges have been identified: coarse (PM10-PM2.5), fine (PM2.5), and ultrafine (Below 0.1micron). Although there are overlaps in particle size distribution and sources, some patterns have emerged. Combustion, high temperature processes, and atmospheric transformation processes are implicated in the formation of fine particles while coarse particles are typically generated by mechanical processes. Chemical composition of particulate matter varies from region to region. For example, fine particles from the eastern US have more sulfate than those from the west (47% vs. 15% as stated in Wilson and Spengler, 1996); conversely, the western particles have twice the proportion of organic carbon than the eastern (38.9% vs. 20.9%).

Participants at the PM Measurements Research Workshop (EPA, 1998) developed a list of eleven common hypotheses about particle characteristics that might be important for health effects. The list was developed to help communicate the ideas of the health researchers to scientists from other disciplines and should not be viewed as the consensus of the health community. Nonetheless, the list can help determine important measurement parameters and research priorities for source reduction and control technology research.

Hypotheses from the PM Measurements Research Workshop (EPA, 1998)

1. PM Mass concentration - Studies have indicated that a PM mass-health relationship exists. However, the document notes that PM includes a variety of materials having different characteristics.

2. PM Particle Size/Surface Area - Studies have shown that, for deposition in the lung, toxicity tends to increase as particle size decreases. Three reasons are given: finer particles penetrate more readily; finer particles have greater surface area per unit of mass; and finer particles dissolve more rapidly in the lungs, enhancing bioavailability of solubilized agents.

3. Ultrafine PM - Ultrafines are particles with diameters of 0.1 micron or less. The importance of ultrafines is still uncertain; however, increasing attention is being given to them and there are recent epidemiological data suggesting their importance.

4. Metals - Transition metals are known to have cytotoxic and inflammatory properties. It was found that, with residual oil fly ash (ROFA), the soluble metal fraction of the ROFA could be related to the ability of the metal to catalyze production of free radicals in tissues.

5. Acids - Acid aerosols and acidic PM have been shown to have toxic properties.

6. Organic compounds - Organic constituents in PM may act as irritants or allergens. In high-dose laboratory studies, this class of material in ambient samples contained mutagenic species which caused cancer.

7. Biogenic Particles - Biogenic particles, those including bacteria and viruses, pollens, plant and animal detritus, etc, may cause some adverse health effects.

8. Sulfate and Nitrate Salts - Compounds have irritating, cytotoxic and mutagenic properties.

9. Peroxides - Reactive oxygen can cause cellular injury and ambient peroxides comprise one of the several species causing oxidant injury.

10. Soot - As defined by Haynes (1991), "Soot is a carbonaceous solid produced in pyrolysis and combustion systems when conditions are such as to allow gas-phase condensation reactions of the fuel and its decomposition products to compete with further decomposition and oxidation." Formation begins with a condensed phase material forming particles; surface growth and coagulation are responsible for particle growth. Elemental carbon has been found to cause tissue irritation and the release of toxic chemical intermediates from scavenger cells. Soot, which is comprised of an elemental carbon matrix and adsorbed organics and inorganics, can be an irritant, mutagenic, and possibly carcinogenic.

11. Cofactors - Other exposure related factors may be associated with adverse health effects. Co-pollutants, such as NOx and SOx are considered to be very important.

Possible Focus of Programs on Source Reduction and Control Technology

The risk reduction options with which the Committee is most familiar are source reduction and control technology. Because a great deal is left to be known about particles, health researchers cannot yet tell engineers which particles to target. Therefore, the initial strategy for defining risk reduction options may be to investigate a range of ideas regarding relevant parameters, for example particle size and composition. This information can be combined with knowledge about the current state of source reduction and control technology to identify where the research might be most useful. The list below illustrates how the health related hypotheses (Table 1) might be linked with source reduction and technology approaches to develop a research plan. This list is not intended to be exhaustive and it should be noted that EPA, through ORD's National Risk Management Research Laboratory, is already conducting some research in response to this need.

1. Assess the adaptability of existing technologies to capture particles of a certain size

A recent survey of Electrostatic Precipitators (ESPs; Sarofim, Senior, and Helble, 1998) indicated that there exists a range of particle size where the efficiency is low (and, therefore, penetration is high), although the data did show some scatter. The range of particle sizes was between 0.1 and 1 micron. ESPs account for approximately 95% of the air pollution control devices for particulate matter on coal combustion systems (McIlvaine, 1998). Effective particulate removal methods would need to be developed for particle sizes within this range if particles in this range are found to be important.

2. Develop source specific PM2.5 chemical fingerprints

The chemical and physical characteristics of inorganic PM2.5 species can be predicted using thermodynamic principles given specific meteorological conditions (e.g., temperature, relative humidity, etc.) and ambient concentrations of PM2.5 (Seinfeld and Pandis, 1998). Many particles are initially formed from condensation of organic vapors or the nucleation of the inorganic precursors. The subsequent coagulation of particles and/or condensation of vapors onto existing particles cause particles to change in size and chemical composition. While some source apportionment studies have been undertaken (Rogge, et al. 1991, 1993, 1994; Shauer, et al. 1996; and Watson and Chow, 1998), given the variability in chemical composition there will still be some missing links unless further source specific PM2.5 chemical fingerprints are developed and validated.

3. Determine the concentration of metals in fine particulate matter as a function of size

Researchers have studied the distribution of metals on particulate matter as a function of size.   More information could be gathered to determine if there are effective combustion techniques that reduce the concentration of "important" (from a health effects standpoint) metals on particulate matter from combustion systems.

4. Sulfur, nitrogen, and organics' control

Atmospheric chemistry and ambient particle characterization studies (as cited previously) indicate that nitrates (Seinfeld and Pandis, 1998) and sulfates production are important to the total PM2.5 inventories. For most areas, secondary particulate matter formation is more important than primary particulate matter formation. This suggests that additional work on NOx, ammonia, and sulfur control is necessary to control these precursors. Aneja (1998) states that, in some states, ammonia represents 40-50% of total nitrogen emissions from all sources.

Conclusions

The Committee suggests that EPA initiate additional research relating to risk management. This research is going to be very important, not only in implementing and meeting future standards, but also in informing the decision-making process about the standards.

The Committee encourages the Agency to think broadly about potential risk reduction options and to undertake research on source reduction and control technology. Sources, ambient concentrations, exposure and risk are linked. The existence of the NAAQS and the lead time needed to identify effective risk reductions strategies are sufficient reasons to initiate a concurrent and complementary risk reduction research program.

Research to identify, develop, and evaluate risk reduction options should be undertaken now. If this is not done, once the health effects studies are completed and the studies point to mechanisms for adverse effects from PM, no strategies may be available to meet the need for source reduction. For this reason, the Committee brings the issue to the EPA for further consideration in its research planning for the next five years to meet and revise the PM standard.

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